

# FINAL PROGRESS REPORT

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Modeling Studies of the Effects of Tropical Rainfall on  
Ocean-Atmosphere Interactions and Oceanic Hydrological Cycle

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This research project is a joint effort of UMD/JCESS, NASA/GSFC, NOAA/PMEL and LDEO, with UMD/JCESS being the leader and LDEO being responsible for coupled modeling. Although the project as a whole is for three years, the LDEO part was terminated at the end of the second year because of a shift of focus. The detailed description of the whole project and the effort made at LDEO have been given in the two joint annual reports and the two annual reports from LDEO. Here we only provide a brief summary of what we have done here at LDEO and a list of publications that resulted partly from this project.

In response to the new challenges posed by the recent El Niño event, we have conducted a series of experiments to evaluate the impact of data assimilation on the forecast skill of the Lamont ENSO prediction model. The model forecasts were greatly improved when satellite scatterometer winds were used for model initialization instead of the traditional wind products based on ship-board observations (Chen et al., 1999a). The improvement is attributed to the much better coverage of the satellite product. In order to predict the development of El Niño, it is crucial to assimilate accurate information into the initial model state. Satellite-derived data sets have the potential to provide such information for real-time forecasting.

Assimilating sea level data also has a strong positive impact on the Lamont model prediction of the 1997/98 El Niño (Chen et al., 1998). The sea level measurements in the vicinity of the equator are extremely effective in correcting the model ocean state and preconditioning it for ENSO prediction. This result is of interest to TRMM because rainfall and salinity contribute significantly to sea level variability. Although sea level changes in our simple model is directly related to that of the thermocline, for more realistic forecast models, assimilating rainfall and salinity data will have to be taken into account. In any case, it is advisable to assimilate multiple data sets so that they can complement one another.

To make effective use of observational data, we need to know the sensitivity of model simulations to the spatial and temporal resolution of observed fields. We have performed a total of 16 experiments using the NSCAT wind data smoothed at time intervals from 1 to

30 days and on spatial scales from 1 to 10 degrees (Chen et al., 1999b). The onset of the 1997/98 El Niño can be successfully simulated using the wind forcing averaged to monthly intervals and 2° squares. For climate models, the spatial smoothing of wind forcing on scales larger than the width of the equatorial waveguide is a more serious limitation than the temporal smoothing on scales up to one month. Considering the intermittent nature of rainfall, we expect models to be sensitive to the resolution of freshwater forcing. The same kind of sensitivity studies on rainfall is being conducted.

To evaluate the impact of tropical rainfall observation on ENSO study and prediction, we need a model that is at least as sophisticated as the one we proposed. Although that model runs well in the hindcast mode, it has not yet worked in forecast mode. A major problem is the model/data incompatibility in model initialization. In order to reduce the large systematic model biases, we have worked out a method based on the regression between the leading EOFs of the model errors and the leading MEOFs of the model states (Chen et al., 2000). The bias-corrected model not only performed better in ENSO forecasting, but also exhibits a more realistic internal variability. Having such a model makes it more straightforward to assimilate data, including rainfall data, for model initialization.

In summary, our modeling studies have demonstrated the positive impact of satellite measurements in climate prediction and the necessity of assimilating multiple data sets for model initialization. The bias-correction method we have developed will pave the way for assimilating data, including TRMM data, into coupled ocean-atmosphere models.

## Publications

Chen, D., M. A. Cane, S. E. Zebiak and A. Kaplan, 1998: The impact of sea level data assimilation on the Lamont model prediction of the 1997/98 El Niño, *Geophys. Res. Lett.*, 25, 2837-2840.

Chen, D., M. A. Cane, and S. E. Zebiak, 1999a: The impact of NSCAT winds on predicting the 1997/98 El Niño: A case study with the Lamont-Doherty Earth Observatory model, *J. Geophys. Res.*, 104, 11321-11327.

Chen, D., T. Liu, S. E. Zebiak, M. A. Cane, Y. Kushnir and D. Witter, 1999b: Sensitivity of the tropical Pacific ocean simulation to the spatial and temporal resolution of wind forcing, *J. Geophys. Res.*, 104, 11261-11271.

Chen, D., M. A. Cane, S. E. Zebiak, Rafael Canizares and A. Kaplan, Bias correction of an ocean-atmosphere coupled model. *Geophys. Res. Lett.*, in press, 2000.